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Lafayette County, Arkansas

National Eutrophication Survey, Las Vegas, Nev

Prepared for

Environmental Monitoring and Support Lab, Las Vegas, Nev

Jan 77

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NATIONAL EUTROPHICATION SURVEY

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REPORT
ON
LAKE ERLING
LAFAYETTE COUNTY
ARKANSAS
EPA REGION VI
WORKING PAPER No. 486

WITH THE COOPERATION OF THE
ARKANSAS DEPARTMENT OF POLLUTION
CONTROL AND ECOLOGY
AND THE
ARKANSAS NATIONAL GUARD
JANUARY, 1977

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16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

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REPORT ON LAKE ERLING

LAFAYETTE COUNTY, ARKANSAS

EPA REGION VI

by

National Eutrophication Survey

Water and Land Monitoring Branch
Monitoring Applications Laboratory
Environmental Monitoring & Support Laboratory
Las Vegas, Nevada

and

Eutrophication Survey Branch
Corvallis Environmental Research Laboratory
Corvallis, Oregon

Working Paper No. 486

OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY

January 1977

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point source discharge reduction and nonpoint source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's freshwater lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by the U.S. Environmental Protection Agency and to augment plans implementation by the states.

ACKNOWLEDGMENTS

The staff of the National Eutrophication Survey (Office of Research and Development, U.S. Environmental Protection Agency) expresses sincere appreciation to the Arkansas Department of Pollution Control and Ecology for professional involvement, to the Arkansas National Guard for conducting the tributary sampling phase of the Survey, and to those Arkansas wastewater treatment plant operators who provided effluent samples and flow data.

The staff of the Water Division of the Arkansas Department of Pollution Control and Ecology provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports and provided critiques most useful in the preparation of this Working Paper series.

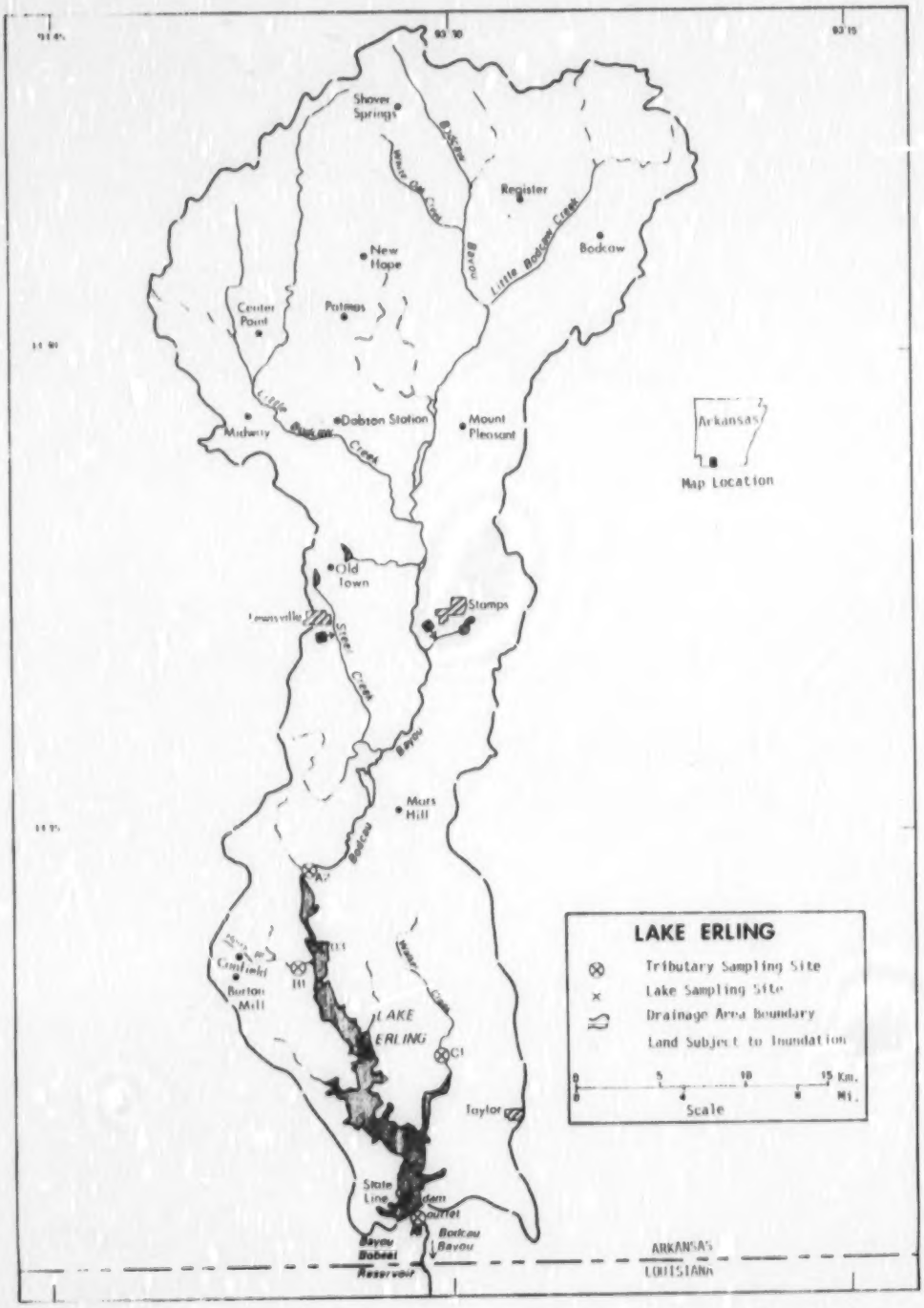
Major General Thomas C. Armstrong, the Adjutant General of Arkansas, and Project Officer Colonel Lavaun M. James, who directed the volunteer efforts of the Arkansas National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF ARKANSAS

LAKE NAME	COUNTY
Beaver	Benton, Carroll, Washington
Blackfish	Crittenden, St. Francis
Blue Mountain	Logan, Yell
Bull Shoals	Baxter, Boone, Marion (Taney, Ozark in MO)
Catherine	Garland, Hot Spring
Chicot	Chicot
DeGray	Clark, Hot Spring
Erling	Lafayette
Grand	Chicot
Greer's Ferry	Van Buren, Cleburne
Hamilton	Garland
Millwood	Hempstead, Howard Little River, Sevier
Nimrod	Perry, Yell
Norfork	Baxter, Fulton (Ozark in MO)
Ouachita	Garland, Montgomery
Table Rock	Boone, Carroll (Barry, Taney in MO)


Shover Springs
Register
New Hope
Bodcaw
Center Point
Patmos
Dabton Station
Mount Pleasant
Arkansas
Map Location
Old Town
Stamps
Mars Hill
Burton Mill
LAKE ERLING
Taylor
State Line
Bayou Bodcau Reservoir
ARKANSAS
LOUISIANA
LAKE ERLING
Tributary Sampling Site
Lake Sampling Site
Drainage Area Boundary
Land Subject to Inundation
Scale

REPORT ON LAKE ERLING, ARKANSAS

STORET NO. 0508

I. CONCLUSIONS

A. Trophic Condition:*

Lake Erling is considered eutrophic, i.e., nutrient rich and highly productive, on the basis of Survey data and field observations. Whether such nutrient enrichment is to be considered beneficial or deleterious is determined by its actual or potential impact upon designated beneficial water uses of the lake.

Potential for primary production as measured by algal assay control yields was high. Chlorophyll a values ranged from 4.5 µg/l in the spring to 53.0 µg/l in the summer, with a mean of 13.4 µg/l. Of the 16 Arkansas lakes sampled in 1974, 4 had higher median total phosphorus levels, 3 had higher median orthophosphorus values, and 13 had higher median inorganic nitrogen levels than Lake Erling.

Survey limnologists reported abundant aquatic macrophytes in the shallower, northernmost 30% of the reservoir, but otherwise observed no problem conditions in Lake Erling.

* See Appendix E

B. Rate-Limiting Nutrient:

Mean inorganic nitrogen to orthophosphorus (N/P) ratios for the reservoir were 5/1 or less during spring and autumn, indicating primary limitation by nitrogen, and 13/1 during summer, suggesting near colimitation by nitrogen and phosphorus.

Algal assay results indicated primary limitation by nitrogen during spring sampling, and high potential for primary production in Lake Erling.

C. Nutrient Controllability:

1. Point sources -

The mean annual phosphorus load from point sources was estimated to be 10.8% of the total load reaching Lake Erling. The town of Louisville contributed 5.9% of the total and the town of Stamps contributed 4.9%.

The calculated phosphorus loading of 0.86 g $P/m^2/yr$ for Lake Erling is approximately 1.3 times the eutrophic load proposed by Vollenweider (1975) for lakes with such volume and retention time. Removal of phosphorus inputs from the two known point sources would not reduce loading to an oligotrophic level in the lake; however, it should aid in slowing the present rate of eutrophication.

2. Nonpoint sources -

The mean annual load from nonpoint sources, including precipitation, accounted for 89.2% of the total reaching Lake Erling. Bodcau Creek contributed 82.9%, and ungaged tributaries were estimated to have contributed 3.3%.

In general, few lakes are nitrogen limited as a result of low nitrogen. Rather, excessive phosphorus levels shift limitations to nitrogen or other factors. Regardless of the primary nutrient limitation suggested by either algal assay or nutrient ratios, the most feasible approach to nutrient control, if desirable, is through available phosphorus control technology and subsequent establishment of phosphorus limitation within the water body.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS

Lake and drainage basin characteristics are itemized below. Lake surface area and mean depth were provided by the Arkansas Department of Pollution Control and Ecology. Maximum depth was estimated on the basis of Survey data. Tributary flow data were provided by the Arkansas District Office of the U.S. Geological Survey (USGS). Outlet drainage area includes the lake surface area. Mean hydraulic retention time was obtained by dividing the lake volume by the mean flow of the outlet. Precipitation values are estimated by methods as outlined in National Eutrophication Survey (NES) Working Paper No. 175. A table of metric/English conversions is included as Appendix A.

A. Lake Morphometry:

1. Surface area: 28.33 km^2.
2. Mean depth: 2.1 meters.
3. Maximum depth: 9.1 meters.
4. Volume: 60.441 x 10^6 m^3.
5. Mean hydraulic retention time: 67 days.

B. Tributary and Outlet:
(See Appendix B for flow data)

1. Tributaries -

Name	Drainage area (km^2)	Mean flow (m^3/sec)
A-2 Bodcau Creek	787.4	7.96
C-1 Walker Creek	46.9	0.47
Minor tributaries and immediate drainage -	160.5	1.91
Totals	994.8	10.34
2. Outlet - A-1 Bodcau Creek	1,023.0	10.51

C. Precipitation:

1. Year of sampling: 218.3 cm.
2. Mean annual: 125.4 cm.

III. LAKE WATER QUALITY SUMMARY

Lake Erling was sampled three times during the open-water season of 1974 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from three stations on the lake and one or more depths at each station (see map, page v). During each visit, depth-integrated samples were collected from each station for chlorophyll a analysis and phytoplankton identification and enumeration. During the first and last visits, 18.9-liter depth-integrated samples were composited for algal assays. Maximum depths sampled were 7.9 meters at Station 01, 3.0 meters at Station 02, and the surface at Station 03. For a more detailed explanation of NES methods, see NES Working Paper No. 175.

The results obtained are presented in full in Appendix C and are summarized in III-A for waters at the surface and at the maximum depth for each site. Results of the phytoplankton counts and chlorophyll a determinations are included in III-B. Results of the limiting nutrient study are presented in III-C.

LAKE ERLING
STORET CODE 0508

PHYSICAL AND CHEMICAL CHARACTERISTICS

PARAMETER	(3/25/74) S*** = 4 N*	RANGE	MEDIAN	MAX DEPTH RANGE (METERS)	(6/ 3/74) S*** = 4 N*	RANGE	MEDIAN	MAX DEPTH RANGE (METERS)	(10/17/74) S*** = 3 N*	RANGE	MEDIAN	MAX DEPTH RANGE (METERS)
TEMPERATURE (DEG CENT)												
0.-1.5 M DEPTH	4	12.3- 14.4	14.5	0.0- 1.5	4	25.8- 26.0	25.9	0.0- 1.5	4	18.1- 19.8	19.7	0.0- 1.5
MAX DEPTH**	3	12.3- 14.6	14.5	0.0- 7.6	2	21.2- 25.9	23.5	1.5- 7.9	3	18.1- 19.8	19.6	0.0- 6.4
DISSOLVED OXYGEN (MG/L)												
0.-1.5 M DEPTH	2	6.4- 7.4	6.9	0.0- 1.5	3	4.8- 7.8	5.4	0.0- 1.5	4	5.4- 6.4	5.9	0.0- 1.5
MAX DEPTH**	3	6.4- 8.0	7.6	0.0- 7.6	3	0.4- 7.8	4.8	0.0- 7.9	3	5.0- 6.4	6.2	0.0- 6.4
CONDUCTIVITY (UMHOS)												
0.-1.5 M DEPTH	4	44.- 117.	65.	0.0- 1.5	4	91.- 95.	93.	0.0- 1.5	4	51.- 63.	54.	0.0- 1.5
MAX DEPTH**	3	44.- 117.	65.	0.0- 7.6	2	95.- 112.	104.	1.5- 7.9	3	49.- 57.	51.	0.0- 6.4
PH (STANDARD UNITS)												
0.-1.5 M DEPTH	4	6.1- 6.3	6.3	0.0- 1.5	5	6.5- 7.1	6.7	0.0- 1.5	4	5.4- 5.5	5.5	0.0- 1.5
MAX DEPTH**	3	6.1- 6.3	6.3	0.0- 7.6	3	6.5- 7.1	6.6	0.0- 7.9	3	5.4- 5.5	5.5	0.0- 6.4
TOTAL ALKALINITY (MG/L)												
0.-1.5 M DEPTH	4	10.- 15.	11.	0.0- 1.5	5	10.- 10.	10.	0.0- 1.5	4	10.- 11.	10.	0.0- 1.5
MAX DEPTH**	3	10.- 12.	10.	0.0- 7.6	3	10.- 23.	10.	0.0- 7.9	3	10.- 10.	10.	0.0- 6.4
TOTAL P (MG/L)												
0.-1.5 M DEPTH	4	0.048-0.104	0.054	0.0- 1.5	5	0.040-0.066	0.054	0.0- 1.5	4	0.065-0.131	0.069	0.0- 1.5
MAX DEPTH**	3	0.046-0.104	0.055	0.0- 7.6	3	0.041-0.066	0.054	0.0- 7.9	3	0.061-0.131	0.061	0.0- 6.4
DISSOLVED ORTHO P (MG/L)												
0.-1.5 M DEPTH	4	0.025-0.043	0.029	0.0- 1.5	5	0.008-0.009	0.009	0.0- 1.5	4	0.018-0.074	0.025	0.0- 1.5
MAX DEPTH**	3	0.019-0.043	0.033	0.0- 7.6	3	0.007-0.009	0.009	0.0- 7.9	3	0.015-0.074	0.021	0.0- 6.4
NO2+NO3 (MG/L)												
0.-1.5 M DEPTH	4	0.060-0.150	0.070	0.0- 1.5	5	0.030-0.060	0.030	0.0- 1.5	4	0.020-0.070	0.040	0.0- 1.5
MAX DEPTH**	3	0.070-0.150	0.070	0.0- 7.6	3	0.020-0.030	0.030	0.0- 7.9	3	0.020-0.080	0.020	0.0- 6.4
AMMONIA (MG/L)												
0.-1.5 M DEPTH	4	0.050-0.090	0.055	0.0- 1.5	5	0.030-0.090	0.070	0.0- 1.5	4	0.060-0.160	0.110	0.0- 1.5
MAX DEPTH**	3	0.050-0.090	0.060	0.0- 7.6	3	0.030-0.360	0.080	0.0- 7.9	3	0.070-0.150	0.080	0.0- 6.4
KJELDAHL N (MG/L)												
0.-1.5 M DEPTH	4	0.600-0.700	0.600	0.0- 1.5	5	0.600-1.000	0.800	0.0- 1.5	4	0.500-1.100	0.650	0.0- 1.5
MAX DEPTH**	3	0.500-0.700	0.600	0.0- 7.6	3	0.600-1.000	0.900	0.0- 7.9	3	0.400-1.100	0.500	0.0- 6.4
SECCHI DISC (METERS)	3	1.0- 1.2	1.0		3	1.4- 1.5	1.5		3	0.7- 1.2	1.0	

* N = NO. OF SAMPLES
** MAXIMUM DEPTH SAMPLED AT EACH SITE
*** S = NO. OF SITES SAMPLED ON THIS DATE

B. Biological Characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
03/25/74	1. Melosira	1,843
	2. Cryptomonas	282
	3. Dactylococcopsis	154
	4. Chroomonas	128
	5. Ankistrodesmus	51
	Other genera	435
	Total	2,893
06/03/74	1. Melosira	491
	2. Dactylococcopsis	338
	3. Chroomonas	215
	4. Cryptomonas	31
	5. Microcystis	31
	Other genera	60
	Total	1,166
10/17/74	1. Melosira	1,371
	2. Cryptomonas	190
	3. Oocystis	152
	4. Dactylococcopsis	76
	5. Dictyosphaerium	38
	Other genera	153
	Total	1,980

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (µg/l)
03/25/74	01	7.4
	02	7.1
	03	4.5
06/03/74	01	8.4
	02	13.0
	03	53.0
10/17/74	01	5.3
	02	8.8
	03	13.0

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked - 03/25/74

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum Yield (mg/l-dry wt.)
Control	0.030	0.130	3.2
0.05 P	0.080	0.130	3.9
0.05 P + 1.0 N	0.080	1.130	23.0
1.00 N	0.030	1.130	4.8

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential for primary production in Lake Erling was high at the time of spring assay sample collection. Increases in yield with the addition of nitrogen as well as the lack of significant response to the addition of phosphorus spikes indicates nitrogen limitation. Maximum growth yield was achieved with the simultaneous addition of both nutrients.

The autumn algal assay results are not considered reliable because of a significant change in the nutrient levels between the time the sample was collected and the assay was begun.

Mean N/P ratios in the lake data were 5/1 or less during spring and autumn sampling, indicating primary limitation by nitrogen, and 13/1 in the summer, suggesting near colimitation by phosphorus and nitrogen.

IV. NUTRIENT LOADINGS
(See Appendix D for data)

For the determination of nutrient loadings, the Arkansas National Guard collected near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff months of March and April when two samples were collected. Sampling was begun in June 1974, and was completed in May 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Arkansas District Office of the USGS for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a USGS computer program for calculating stream loadings. Nutrient loads indicated for tributaries are those measured minus known point source loads, if any.

Nutrient loading for unsampled "minor tributaries and immediate drainage" ("ZZ" of USGS) were estimated by using the mean annual nutrient loads, in kg/km^2/yr, in Walker Creek at Station C-1, and multiplying the means by the ZZ area in km^2.

Nutrient loads for the Stamps and Lewisville wastewater treatment plants were estimated at 1.134 kg P and 3.401 kg N/capita/yr.

A. Waste Sources:

1. Known municipal -

Name	Population Served*	Treatment*	Mean Flow ($m^3/d \times 10^3$)	Receiving Water
Stamps	1,050	Primary (mechanically cleaned)	0.397**	Bodcau Bayou
Lewisville	1,255	Stabilization pond	0.475**	Steel Creek/ Bodcau Bayou

2. Known industrial - None

*U.S. EPA, 1971.
**Estimated at 0.3785 m^3/capita/day.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/yr	% of total
a. Tributaries (nonpoint load) -		
A-2 Bodcau Creek	20,110	82.9
C-1 Walker Creek	220	0.9
b. Minor tributaries and immediate drainage (nonpoint load) -	805	3.3
c. Known municipal STP's -		
Stamps	1,190	4.9
Lewisville	1,425	5.9
d. Septic tanks - None		
e. Known industrial - None		
f. Direct precipitation* -	495	2.0
Totals	24,245	100.0

2. Output - A-1 Bodcau Creek 16,095

3. Net annual P accumulation - 8,150

*Estimated (see NES Working Paper No. 175).

B. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (nonpoint load) -		
A-2 Bodcau Creek	240,090	77.8
C-1 Walker Creek	6,785	2.2
b. Minor tributaries and immediate drainage (nonpoint load) -	23,275	7.5
c. Known municipal STP's -		
Stamps	3,570	1.2
Lewisville	4,270	1.4
d. Septic tanks - None		
e. Known industrial - None		
f. Direct precipitation* -	30,585	9.9
Totals	308,575	100.0
2. Outlet - A-1 Bodcau Creek	233,290	
3. Net annual N accumulation -	75,285	

*Estimated (see NES Working Paper No. 175).

D. Mean Annual Nonpoint Nutrient Export by Subdrainage Area:

Tributary	kg P/km^2/yr	kg N/km^2/yr
Bodcau Creek	26	305
Walker Creek	5	145

E. Mean Nutrient Concentrations in Ungaged Streams:

Tributary	Mean Total P (mg/l)	Mean Total N (mg/l)
B-1 Heirs Branch	0.099	1.067

Nutrient levels for Heirs Creek, tributary B-1, are slightly higher than those in the other tributaries entering Lake Erling. This elevation in nutrient levels is possibly due to influences from the town of Canfield.

F. Yearly Loadings:

In the following table, the existing phosphorus annual loading is compared to the relationship proposed by Vollenweider (1975). Essentially, his eutrophic loading is that at which the receiving waters would become eutrophic or remain eutrophic; his oligotrophic loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between eutrophic and oligotrophic.

Note that Vollenweider's model may not apply to lakes with short hydraulic retention times or in which light penetration is severely restricted by high concentrations of suspended solids in the surface waters.

	Total Yearly Phosphorus Loading ($g/m^2/yr$)
Estimated loading for Lake Erling	0.86
Vollenweider's eutrophic loading	0.67
Vollenweider's oligotrophic loading	0.33

V. LITERATURE REVIEWED

U.S. Environmental Protection Agency, 1971. "Inventory of Wastewater Treatment Facilities" EPA Publication No. OWP-1, Office of Media Programs, Office of Water Programs, Washington, D.C.

U.S. Environmental Protection Agency. 1975. National Eutrophication Survey Methods 1973-1976. Working Paper No. 175. National Environmental Research Center, Las Vegas, Nevada, and Pacific Northwest Environmental Research Laboratory, Corvallis, Oregon.

Vollenweider, R.A. 1975. Input-Output Models With Special Reference to the Phosphorus Loading Concept in Limnology. Schweiz. Z. Hydrol. 37:53-84.

VI. APPENDICES

APPENDIX A

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX B

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR ARKANSAS 02/02/77

LAKE CODE 0508 LAKE ERLING

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 1023.0

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
0508A1	1023.0	16.93	20.13	18.07	21.35	21.52	3.57	3.23	1.24	1.02	2.23	6.14	11.27	10.51
0508A2	787.4	12.83	15.23	13.68	16.17	16.31	2.71	2.44	0.94	0.78	1.69	4.64	8.52	7.96
0508C1	46.9	0.753	0.895	0.804	0.949	0.957	0.159	0.144	0.054	0.045	0.099	0.272	0.501	0.467
0508ZZ	188.8	3.06	3.65	3.28	3.88	3.91	0.65	0.58	0.22	0.18	0.40	1.11	2.04	1.91

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 1023.0
SUM OF SUB-DRAINAGE AREAS = 1023.0

TOTAL FLOW IN = 124.54
TOTAL FLOW OUT = 126.70

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
0508A1	6	74	47.572	23	21.238				
	7	74	1.096	21	0.510				
	8	74	0.883	18	0.340				
	9	74	37.661	22	42.475				
	10	74	10.024	19	4.021				
	11	74	38.398	24	38.511				
	12	74	37.293	22	29.733				
	1	75	38.766	18	43.042				
	2	75	60.938	24	24.636				
	3	75	34.093	9	18.689	22	33.980		
	4	75	14.385	5	9.911	20	9.968		
	5	75	55.671	21	39.332				
0508A2	6	74	27.043	23	2.350				
	7	74	0.697	21	0.110				
	8	74	0.892	18	0.442				
	9	74	36.246	22	20.671				
	10	74	5.918	19	4.474				
	11	74	30.582	24	23.248				
	12	74	26.788	22	16.027				
	1	75	23.843	18	24.806				
	2	75	33.980	24	15.518				
	3	75	27.269	9	11.185	22	34.773		
	4	75	9.316	5	8.778	20	8.778		
	5	75	36.670	22	10.704				

TRIBUTARY FLOW INFORMATION FOR ARKANSAS 02/02/77

LAKE CODE 0508 LAKE ERLING

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
0508C1	6	74	1.611	23	0.003				
	7	74	0.042	21	0.003				
	8	74	0.054	18	0.003				
	9	74	2.155	22	0.028				
	10	74	0.354	19	0.003				
	11	74	1.829	24	0.042				
	12	74	1.594	22	0.028				
	1	75	1.419	18	0.042				
	2	75	2.019	24	0.028				
	3	75	1.623	9	0.014	22	0.057		
	4	75	0.566	5	0.014	20	0.014		
	5	75	2.180	22	0.014				
0508ZZ	6	74	6.485	23	0.564				
	7	74	0.167	21	0.028				
	8	74	0.212	18	0.105				
	9	74	8.693	22	4.955				
	10	74	1.422	19	1.076				
	11	74	7.362	24	5.578				
	12	74	6.428	22	3.851				
	1	75	5.720	18	5.947				
	2	75	8.127	24	3.710				
	3	75	6.541	9	2.682	22	8.325		
	4	75	2.237	5	2.110	20	2.110		
	5	75	8.807	21	2.832	22	2.568		

APPENDIX C

PHYSICAL AND CHEMICAL DATA

STORET RETRIEVAL DATE 77/02/02

050601
33 02 52.0 093 31 20.0 3
LAKE ERLING
05073 ARKANSAS 101691

/TYPA/AMBNT/LAKE

11EPALES 04001002
0030 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
74/03/25	10 00	0000	14.8		38	44	6.30	15	0.060	0.600	0.070	0.025
	10 00	0006	14.7	8.2		47	6.30	13	0.050	0.500	0.070	0.035
	10 00	0025	14.6	8.0		48	6.30	12	0.060	0.500	0.070	0.033
74/06/03	09 25	0000	26.0		60	91	7.15	10K	0.070	0.900	0.060	0.009
	09 25	0005	25.8	5.4		91	6.70	10K	0.070	0.600	0.040	0.008
	09 25	0015	25.3	4.4		90	6.45	10K	0.090	0.600	0.030	0.006
	09 25	0026	21.2	0.4		112	6.60	23	0.360	0.900	0.020	0.007
74/10/17	10 00	0000	19.7	5.6	26	51	5.53	11	0.160	0.700	0.060	0.024
	10 00	0005	19.7	5.4		51	5.53	10	0.140	0.500	0.070	0.026
	10 00	0021	19.6	5.0		49	5.51	10	0.150	0.500	0.080	0.021

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
74/03/25	10 00	0000	0.048	7.4	
	10 00	0006	0.047		
	10 00	0025	0.046		
74/06/03	09 25	0000	0.043	8.4	50.0
	09 25	0001			1.0
	09 25	0003			
	09 25	0005	0.040		
	09 25	0015	0.040		
	09 25	0026	0.041		
74/10/17	10 00	0000	0.071	5.3	
	10 00	0005	0.065		1.0
	10 00	0006			
	10 00	0021	0.061		

K VALUE KNOWN TO BE
LESS THAN INDICATED

32

STORET RETRIEVAL DATE 77/02/02

050502
33 04 25.0 093 33 22.0 3
LAKE ERLI...
05073 ARKANSAS
101691

/TYPA/AMBNT/LAKE

11EPALES 04001002
0014 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
74/03/25	10	15 0000	14.6		38	64	6.30	11	0.050	0.600	0.070	0.030
	10	15 0005	14.5	7.4		65	6.30	10	0.050	0.600	0.060	0.028
	10	15 0010	14.5	7.6		65	6.30	10K	0.050	0.600	0.070	0.019
74/06/03	10	10 0000	25.9		54	95	6.50	10	0.090	0.800	0.030	0.009
	10	10 0005	25.9	4.8		95	6.50	10K	0.080	0.600	0.030	0.009
74/10/17	10	25 0000	19.8	6.2	38	63	5.53	10K	0.060	0.600	0.020	0.016
	10	25 0006	19.8	6.2		51	5.53	10K	0.070	0.400	0.020K	0.015

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
74/03/25	10	15 0000	0.055	7.1	
	10	15 0005	0.054		
	10	15 0010	0.055		
74/06/03	10	10 0000	0.054	13.0	
	10	10 0001			50.0
	10	10 0003			1.0
	10	10 0005	0.054		
74/10/17	10	25 0000	0.067	8.8	
	10	25 0006	0.061		1.0

K VALUE KNOWN TO BE
LESS THAN INDICATED

33A

STORET RETRIEVAL DATE 77/02/02

050803
33 11 24.0 093 35 08.0 3
LAKE ERLIN
05073 ARKANSAS

/TYPA/AMENT/LAKE

101691

11EPALES
0004 FEET DEPTH CLASS 00 0+001002

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
74/03/25	10	30 0000	12.3	6.4	48	117	6.10	10	0.090	0.700	0.150	0.043
74/06/03	10	25 0000		7.8	60		7.10	10K	0.030	1.000	0.030	0.009
74/10/17	10	40 0000	18.1	6.4	46	57	5.37	10K	0.080	1.100	0.020	0.074

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
74/03/25	10	30 0000	0.104	4.5	
74/06/03	10	25 0000	0.066	53.0	
74/10/17	10	40 0000	0.131	13.0	
	10	40 0004			1.0

K VALUE KNOWN TO BE
LESS THAN INDICATED

34

APPENDIX D

TRIBUTARY DATA

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STORET RETRIEVAL DATE 75/11/26
NATL EUTROPHICATION SURVEY
EPA- LAS VEGAS

05038A1
33 02 50.0 093 31 22.0
BOSCAU CREEK
05 7.5 BRADLEY SE
D/LAKE BELING
2NDRY RD BRDG 0.1 MI S OF LK BELING DAM
11&PALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/06/23	12 20		0.008	0.400	0.015	0.010	0.040
74/07/21	15 20		0.016	0.700	0.050	0.025	0.060
74/08/18	19 45		0.024	0.600	0.110	0.030	0.040
74/09/22	14 20		0.024	0.600	0.075	0.005	0.025
74/10/19	07 50		0.080	1.000	0.105	0.020	0.060
74/11/24	17 10		0.088	0.800	0.080	0.025	0.070
74/12/22	16 04		0.040	0.500	0.050	0.030	0.040
75/01/18	14 50		0.032	0.400	0.016	0.015	0.035
75/02/24	16 10		0.032	0.500	0.032	0.016	0.050
75/03/09	10 35		0.016	0.900	0.040	0.024	0.070
75/03/22	15 00		0.015	0.650	0.015	0.015	0.040
75/04/05	10 30		0.015	0.700	0.035	0.010	0.050
75/04/20	15 15		0.010	0.550	0.045	0.010	0.040
75/05/21			0.195	0.800	0.035	0.015	0.060

STORET RETRIEVAL DATE 75/11/28
NATL EUTROPHICATION SURVEY
EPA- LAS VEGAS

050842
33 13 50.0 093 35 15.0
[illegible]
05 7.5 BRADLEY NE
T/LAKE SEELING
BNK S OF GAS WELL IN SEC 33
11EPALES 2111204
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/06/23	11 30		0.080	0.900	0.050	0.060	0.145
74/07/21	14 20		0.008	0.800	0.030	0.045	0.135
74/08/18	19 30		0.016	0.600	0.015	0.040	0.075
74/09/22	12 50		0.024	0.700	0.065	0.045	0.070
74/10/19	06 45		0.032	0.600	0.095	0.045	0.100
74/11/24	16 50		0.016	0.700	0.032	0.020	0.100
74/12/22	15 02		0.008	0.400	0.025	0.005	0.030
75/01/18	14 00		0.008	1.400	0.016	0.030	0.140
75/02/24	15 15		0.016	0.500	0.016	0.024	0.060
75/03/09	09 11		0.024	1.100	0.028	0.028	0.090
75/03/22	14 10		0.006	1.250	0.018	0.015	0.050
75/04/05	09 45		0.015	2.000	0.100	0.040	0.110
75/04/20	14 05		0.015	0.550	0.035	0.035	0.070
75/05/22			0.075	1.650	0.035	0.015	0.105

STORET RETRIEVAL DATE 75/11/28
NATL EUTROPHICATION SURVEY
EPA- LAS VEGAS

050881
43 07 50.2 093 35 40.0
PERKS BRANCH
05 7.5 BRADLEY NE
T/LAKE ERLING
BRDG ON UNIMPROVED RD 1 MI SE FM 360 JCT
11cPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/06/23	11 35		0.016	1.500	0.250	0.090	0.165
74/07/21	14 40		0.004	1.100	0.075	0.020	0.090
74/08/18	19 30		0.016	0.850	0.025	0.065	0.122
74/09/22	13 55		0.024	1.200	0.075	0.030	0.065
74/10/19	07 10		0.016	1.150	0.065	0.045	0.100
74/11/24	15 40		0.024	1.350	0.080	0.030	0.090
74/12/22	15 22		0.016	0.600	0.020	0.025	0.060
75/02/24	15 40		0.024	0.850	0.016	0.032	0.090
75/03/09	09 35		0.016	0.800	0.024	0.024	0.110
75/03/22	14 35		0.010	0.800	0.315	0.022	0.080
75/04/05	10 05		0.020	1.350	0.060	0.030	0.100
75/04/20	14 30		0.020	1.150	0.090	0.040	0.110
75/05/22	13 50		0.020		0.045	0.020	

STORET RET-LEVAL DATE 75/11/28
NATL EUTROPHICATION SURVEY
PRE- LAS VEGAS

05 0301
33 10 45.? 093 30 25.0
WALKER CREEK
05 7.5 BRADLEY NE
T/LAKE FILING
BRDG ON UNIMPROVED RD 0.4 MI E RD 53 JCT
11ERALES 2111204
4 0003 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/06/23	12	45	0.036	1.300	0.330	0.095	0.165
74/07/21	15	35	0.009	1.000	0.085	0.105	0.230
74/08/18	20	30	0.012	1.100	0.085	0.130	0.220
74/09/22	14	45	0.040	0.800	0.035	0.050	0.085
74/10/19	08	15	0.008	0.600	0.030	0.055	0.110
74/11/24	17	25	0.016	0.900	0.060	0.040	0.110
74/12/22	15	45	0.040	0.500	0.030	0.015	0.040
75/01/18	15	05	0.016	0.400	0.016	0.015	0.040
75/02/24	16	20	0.016	0.700	0.016	0.016	0.050
75/03/09	10	30	0.008	0.900	0.040	0.016	0.090
75/03/22	15	30	0.006	0.800	0.030	0.015	0.040
75/04/05	10	50	0.005	0.650	0.015	0.020	0.050
75/04/20	15	30	0.070	0.650	0.090	0.030	0.060
75/05/22	14	30	0.015	0.750	0.035	0.015	0.050

APPENDIX E

PARAMETRIC RANKINGS OF LAKES SAMPLED BY NES IN 1974

STATE OF ARKANSAS

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LAKE DATA TO BE USED IN HAWKINS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	SDG-MEAN SEC	MEAN CHLORA	1S-MIN DO	MEDIAN DISS ORTHO P
0501	BEAVER LAKE	0.022	0.330	415.667	3.921	14.900	0.006
0502	BLACKFISH LAKE	0.424	1.470	496.125	19.775	12.000	0.090
0503	BLUE MOUNTAIN LAKE	0.058	0.160	484.000	8.983	14.600	0.010
0504	BULL SHOALS LAKE	0.015	0.380	343.969	3.995	15.000	0.004
0505	LAKE CATHE-INE	0.029	0.180	451.667	14.042	11.800	0.006
0506	LAKE CHICOT	0.162	0.450	486.000	13.722	14.800	0.089
0507	DEGRAY RESERVOIR	0.019	0.130	419.050	12.300	15.000	0.004
0508	LAKE ERLING	0.054	0.120	454.667	13.389	14.600	0.020
0509	GRAND LAKE	0.101	0.090	479.667	62.467	8.400	0.021
0510	LAKE HAMILTON	0.024	0.130	428.111	10.889	14.400	0.006
0511	MILLWOOD LAKE	0.040	0.120	466.778	14.967	9.800	0.008
0512	NIMROD LAKE	0.039	0.160	469.000	15.833	8.800	0.006
0513	NORFOLK LAKE	0.015	0.320	356.321	3.441	15.000	0.005
0514	LAKE OUACHITA	0.015	0.155	389.144	4.344	15.000	0.006
0515	TABLE ROCK LAKE	0.022	0.350	410.778	9.103	15.000	0.007
0516	GREER'S LAKE	0.012	0.140	370.475	3.762	15.000	0.004

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P
0501	BEAVER LAKE	63 (9)	27 (4)	87 (13)	87 (13)	40 (6)	63 (9)
0502	BLACKFISH LAKE	0 (0)	0 (0)	0 (0)	7 (1)	73 (11)	0 (0)
0503	BLUE MOUNTAIN LAKE	20 (3)	47 (7)	13 (2)	67 (10)	57 (8)	27 (4)
0504	BULL SHOALS LAKE	90 (13)	13 (2)	100 (15)	80 (12)	17 (0)	93 (13)
0505	LAKE CATHERINE	47 (7)	40 (6)	47 (7)	27 (4)	80 (12)	63 (9)
0506	LAKE CHICOT	7 (1)	7 (1)	7 (1)	33 (5)	47 (7)	7 (1)
0507	DEGRAY RESERVOIR	73 (11)	77 (11)	60 (9)	47 (7)	17 (0)	93 (13)
0508	LAKE ERLING	27 (4)	90 (13)	40 (6)	40 (6)	57 (8)	20 (3)
0509	GRAND LAKE	13 (2)	100 (15)	20 (3)	0 (0)	100 (15)	13 (2)
0510	LAKE HAMILTON	53 (8)	77 (11)	53 (8)	53 (8)	67 (10)	63 (9)
0511	MILLWOOD LAKE	33 (5)	90 (13)	33 (5)	20 (3)	87 (13)	33 (5)
0512	NIMROD LAKE	40 (6)	53 (8)	27 (4)	13 (2)	93 (14)	47 (7)
0513	NORFOLK LAKE	80 (12)	33 (5)	93 (14)	100 (15)	17 (0)	80 (12)
0514	LAKE OUACHITA	90 (13)	60 (9)	80 (12)	73 (11)	17 (0)	63 (9)
0515	TABLE ROCK LAKE	63 (9)	20 (3)	73 (11)	60 (9)	17 (0)	60 (8)
0516	GREER'S LAKE	100 (15)	67 (10)	87 (13)	93 (14)	17 (0)	93 (13)